

## A Survey of the Bees of the Black Rock Forest Preserve, New York (Hymenoptera: Apoidea)

VALERIE GILES AND JOHN S. ASCHER\*

Division of Invertebrate Zoology American Museum of Natural History,  
Central Park West at 79<sup>th</sup> Street, New York, NY 10024, USA

\*Address for correspondence: ascher@amnh.org

---

*Abstract.*—We present the results of a survey of the bee fauna of Black Rock Forest, Orange County, New York, USA. The survey focused on bees, with more limited data gathered for other incidentally collected groups such as apoid and vespid wasps. Surveys in 2003 with nets and bowls recorded 144 bee species (26 genera), 22 vespid species (9 genera) and 23 crabronid species (12 genera). Noteworthy records are detailed. A preliminary checklist of the bee fauna of the BRF is presented and discussed in relation to that of New York State, selected sites within the state, and of the northeastern USA as a whole. The cleptoparasitic species *Sphecodes fattigi* Mitchell, *Sphecodes johnsonii* Lovell, and *Lasioglossum (Dialictus) michiganense* (Mitchell), and the oligolectic species *Osmia (Melanosmia) inermis* (Zetterstedt) are newly recorded from New York State. Ecological patterns pertaining to sociality, nest type, pollen specialization, parasitism, and phenology, are summarized and discussed, as are the efficacies of different collecting methods. The net collected sample was richer than the bowl trapped sample in total bee species (117 vs. 113) and in the number of unique species (29, 20.4% vs. 25, 17.6%).

*Key words.*—native bees, *Bombus*, *Audrena*, Apidae, invertebrate survey, invertebrate biodiversity, bowl trap, pan trap, trap nest, Black Rock Forest, pollination

---

Bees (Hymenoptera: Apoidea) are the single most important animal pollinators of both native and cultivated vegetation in most habitats worldwide (Williams et al. 2001, Michener 2000). The mutualist relationship between bees and plants forms a key process in the maintenance of both local biological diversity and agricultural productivity. As primary pollinators, bees provide a vital ecosystem service, affecting the integrity of ecological communities as a whole, including the health of humans (Williams et al. 2001, Nilsson 2000, Cane and Tepedino 2001). Despite this ecological importance, our understanding of some basic aspects of bee biology, including species level distributional patterns, remains incomplete. There are about 20,000 species of bees worldwide (Michener 2000) and approximately 3500 described species occur in America north of Mexico (JSA and

T. Griswold, unpublished; cf. Hurd 1979). Published data on the distribution of bees in New York State (NY) is limited (e.g., Leonard 1928), but Ascher (unpublished information) has compiled a list of 423 species known from New York, of which 405 are native to North America.

Single-site inventories of poorly known invertebrate groups have the potential to establish useful quantitative baseline estimates of local biodiversity, as well as to help illuminate large-scale distributional patterns within those groups. Such estimates can prove useful in testing hypotheses arising from practices as diverse as theoretical biogeography and conservation planning. In addition, geo-referenced specimen data are amenable to re-analysis and comparison with related data sets in the context of regional studies of biodiversity across diverse groups. Finally, such in-

ventories help to address the need for natural history information that is crucial for understanding community-level ecological patterns (e.g. phenological patterns, host associations, habitat use, etc).

Black Rock Forest (BRF) harbors a variety of distinct habitat types, many of which are typical of the larger Hudson Valley Region, and is managed in part as a long-term research preserve. Because the landscape matrix surrounding BRF is under increasing pressure from land conversion and habitat degradation, a survey of the bee communities of BRF while surrounding habitats are still relatively intact should provide a valuable basis for future comparison with a variety of other sites across a range of spatial and temporal scales. The effects of environmental change on bee communities remain insufficiently understood. Many relevant studies have been published (see, e.g., Matheson et al. 1996), but few of these are from eastern North America. Cane (2005) notes that bees "possess a unique combination of salient foraging and nesting traits that together set them apart from other taxa studied in the context of habitat fragmentation". Many bees utilize open areas for foraging and nesting, and may benefit from forest fragmentation, unlike forest-dwelling songbirds. However, bees are still potentially vulnerable to habitat change, particularly the loss of their host plants.

#### RESEARCH OBJECTIVES

This survey was undertaken with two primary goals; first, to assemble a faunal list of the bees (and selected aculeate wasps) of BRF to serve as a baseline inventory of use to both ecologists and conservation biologists, and second, to compare BRF data with other bee samples in order to shed light on larger-scale (regional) patterns of bee distributions and diversity. Second order objectives included enhanced representation of the regional bee fauna in the collection of the American Museum of Natural History

(AMNH) and creation of a synoptic (taxonomic reference) collection to be housed at BRF. Ecological data were also gathered, such as abundance of bees across the season and on selected host plants, and the efficacies of various collecting methods (net collecting vs. trapping with bowls of three different colors vs. trap nesting) were tested.

#### STUDY SITE AND METHODS

The Black Rock Forest (BRF) is a 1520 hectare preserve and research facility located in Orange County, New York (Lat. 41.42267, Long. 74.03039), ca. 50 miles north of New York City (NYC). The BRF is situated within the highest portion of the Hudson Highlands. The terrain comprising the preserve ranges in elevation from about 135 m to 446 m. A network of closed canopy dirt roads permits access to within 1 kilometer of any point within the BRF. The landscape, both within the forest preserve, and across several large adjacent tracts (including West Point Military Academy), is mostly forested (upland hardwood forests dominated by *Quercus* spp., Barringer and Clemants 2003). Other local habitat types include successional hardwood stands, hemlock coves, chestnut-oak woods, red maple swamps, ponds, reservoirs, and marshes. Important habitats for bees at BRF include small meadows, exposed road edges and reservoir edges, dams, and marshes, where flowering shrubs (such as *Viburnum* spp., *Ilex verticillata* (L.) A. Gray, *Kalmia latifolia* L., *Clethra alnifolia* L., *Spiraea* spp., *Rhododendron* spp.), and herbs (such as *Veronica*, *Polygonum* spp., *Gnaphalium*, *Solidago* spp., and *Viola* spp.) provide seasonal sources of pollen and nectar to bees. In addition, during early spring (April) prior to leaf-out, forest habitats hosted bees attracted to flowering trees such as *Acer rubrum* L., *Salix* spp. including *S. discolor* Muhl. and *Prunus* spp. In May, other flowering trees such as *Craetaegus macrosperma* Ashe. and other *Prunus* spp. were important re-

sources for many *Andrena* and other bee species. The early spring flower *Erythronium americanum* Ker-Gawler flowered sparingly during our survey season and was visited by relatively few bees. *Vaccinium* species, especially highbush blueberry *Vaccinium corymbosum* L. and lowbush blueberry *V. angustifolium* Ait. dominated large areas of the forest understory at BRF, including dry hillsides, damp forest areas, open forest gaps created by fires, and wet marsh edges in association with herbaceous communities. Beginning in May, and continuing into late June, *Vaccinium* stands composed of several species were visited by large concentrations of nectaring and "buzz" pollen-collecting bees. *Vaccinium stamineum* L. (Deerberry) was moderately common in hillside forests. Patches of *Lysimachia* were noted.

The survey season during the spring and summer of 2003 was generally wet and cool in southern New York as confirmed by weather data collected at BRF. Above average rainfall and below average temperatures would be expected to depress bee numbers and collecting success.

*Sampling schedule.*—We conducted bee surveys at BRF during 24 days between 31 March 2003 and 16 October 2003. Each survey day began at approximately 0730 hr and was completed generally between 1800 hr and 1900 hr. Most fieldwork was conducted on days with predominantly sunny skies and warm temperatures. Collection sites visited per sampling day and the time spent at each site varied. In addition, individual collecting sites were chosen throughout the BRF property opportunistically in response to the presence of bees or abundance of flowering plants. UTM coordinates were recorded for all sites where bees were collected.

*Sampling methods.*—We collected bees at BRF using 3 principal methods: colored plastic pan (or bowl) traps, hand-held insect nets, and wooden trap nests. Bowl traps were made from 6 oz. plastic Solo brand bowls that were spray-painted with

one of three florescent colors: yellow, white or blue. A total of 150 traps were deployed on each of 17 survey visits and arrayed in ten transects on each visit. Each transect consisted of 15 traps (five of each color), arrayed in alternating colors. Traps contained a solution of Dawn brand blue dishwashing liquid (1 table spoon to 1 gallon tap water) and were placed in ten sites on the ground along transect lines. Traps were deployed over a period of approximately 1 hour beginning at 0730 hr and were in place before 0900 hr on survey visits during which they were used. Individual traps were placed at approximately one meter apart. Transect sites were chosen opportunistically and included: open fields, roadsides, reservoir edges, dams, forest floors and stone outcroppings throughout the BRF property. At the close of each survey visit the traps were retrieved during a two-hour period beginning at approx. 1600 hr. The contents were poured through sieves and the recovered specimens were transferred to plastic whirl-packs containing 75% ethyl alcohol. Locality data and bowl trap color labels were recorded.

Hand netting of bees was conducted between 09:00 and 16:00 during 23 survey visits. Collecting by hand-net was undertaken opportunistically at sites where bees were thought to be concentrated. Hand netting was pursued most intensively in exposed sunny habitats such as fields, road edges, reservoir and marsh edges, where many shrubs and herbaceous perennials bloom and where bees were most likely to occur. When bees were captured they were transferred to cyanide killing jars before being stored in vials. Vials were labeled and placed in a cooler for transfer to the laboratory.

Twenty wooden 'Binderboard' brand trap-nests were deployed for the duration of the survey beginning on 27 May 2003. Ten trap-nests consisted of a wooden block bearing 39 holes, each measuring 5.5 mm diameter, and a depth of 10 cm. The

remaining 10 trap-nests were similar in other respects, but each bore 21 holes measuring 5 mm in diameter, drilled to a depth of 16 cm. Each hole was lined with a kraft paper tube to facilitate recovery of specimens. Trap-nests were mounted in sets of two, at 10 sites dispersed across the BRF property. Each nest was hung from a tree limb approximately 1.5 meters above the ground with the holes oriented to face south. Trap nests were checked periodically to determine if any Hymenoptera had inhabited the holes and to ensure that they were intact and undisturbed. Trap nests were retrieved from BRF on 20 March 2004, and each trap-nest was examined in the laboratory for evidence of occupation by Hymenoptera.

Specimens were sorted, mounted, and identified to species by the authors (initially sorted by VG; species determinations then made or confirmed by JSA) except the more difficult metallic *Lasioglossum* (*Dialictus*) females, determined by S. Droege, Vespidae, determined by J. M. Carpenter, and the more difficult Crabronidae, determined by P. Gambino. S. Droege made, confirmed, and revised identifications for numerous *Nomada*, and L. Day made and confirmed identifications of *Bombus sander-soni* and *B. vagans*. Vouchers are deposited in the collection of the American Museum of Natural History (AMNH). A synoptic collection is housed at the BRF research facility. Duplicate specimens were dispersed to various bee specialists.

Comparative data on the North American bee fauna as a whole, and on the fauna of New York State (NY), and of particular areas within NY, were compiled by JSA based on study of relevant taxonomic and faunistic literature and study of historical insect collections, especially those housed at: AMNH; Cornell University (CUIC); New York State Museum; National Museum of Natural History; University of Connecticut Insect Collections, Storrs; and Parker Gambino's personal collection (affiliated with the AMNH). Recent collec-

tions from across NY and from nearby states such as Connecticut were available, including material collected by the authors, P. Gambino, S. W. T. Batra, K. N. Magnacca, B. N. Danforth, D. L. Wagner, R. G. Goelet and their associates. All discussion of the past and present status and life histories of bee species found at BRF is based, in part, on these historical and recent collections and the literature in addition to the sample obtained during the survey of BRF. Totals cited for "southern New York" are for the area encompassing New York City (NYC), Long Island, and all counties adjacent to Orange County (i.e. the southeast portion of the state north to Sullivan, Ulster, and Dutchess Counties).

## RESULTS AND DISCUSSION

The survey collected and individually databased 6,542 bee specimens representing 144 species, of which 138 are native and six are exotic (Appendix 1), 26 genera, and five families (Table 1). Of these, several records detailed below represent notable range extensions, the only recent known collection of a species in NY, or otherwise fill gaps in the known distributions of New York State bees. Other aculeate specimens incidentally sampled included 22 vespidae species (9 genera), 24 crabronid species (13 genera), and 2 species of *Isodontia* (Sphecidae *sensu stricto*) (Appendix 2). Only a single bee, an *Osmia cornifrons* female, emerged from our trap nests. These were occupied primarily by eumenine (Vespidae) and *Trypoxylon* (*Trypoxylon*) (Crabronidae) wasps and were not examined in detail due to the lack of bees.

*Species totals.*—Of the 144 bee species found at BRF we regard 138 as native to North America (Appendix 1). These are discussed first followed by the six species known or suspected to have been introduced deliberately or accidentally to North America from Europe or East Asia.

*Native bee species.*—

Table 1. Summary of the number of described bee species for each genus known from New York State, with totals for the Eastern USA (sensu Mitchell 1960, 1962), New York State (NY), southern NY as defined in the text (SNY), Black Rock Forest (BRF), New York City (NYC; i.e. the five boroughs), and Ithaca (within city limits; many additional species are known from the Ithaca vicinity in Tompkins Co.). The number of species not native to North America (i.e. adventive and introduced species) is given in parentheses following the total number of species. \*No recent records.

Superfamily Apoidea: Clade Anthophila (Bees)	EUSA	NYS	SNY	BRF	NYC	Ithaca
Family Colletidae:						
Subfamily Colletinae						
<i>Colletes</i>	35	17	7	2	7	6
Subfamily Hylaeinae: Tribe Hylaeini						
<i>Hylaeus</i>	24(3)	14(2)	8(2)	2	8(3)	10(2)
Family Halictidae						
Subfamily Rophitinae: Tribe Rophitini						
<i>Dufourea</i>	3	1	1	0	0	0
Subfamily Halictinae						
Tribe Augochlorini						
<i>Augochlorella</i>	3	1	1	1	1	1
<i>Augochlora</i>	1	1	1	1	1	1
<i>Augochloropsis</i>	3	1	1	1	1	1
Tribe Caenohalictini						
<i>Agapostemon</i>	4	4	4	2	3	3
Tribe Halictini						
Subtribe Sphecodina						
<i>Sphecodes</i>	34	25	15	4	8	13
Subtribe Halictina						
<i>Halictus</i>	5	4	3	3	3	3
<i>Lasioglossum</i>	114(2)	67(2)	39(1)	29(1)	25(1)	44(2)
Family Andrenidae						
Subfamily Andreninae: Tribe Andrenini						
<i>Andrena</i>	125(1)	87(1)	70(1)	40(1)	58(1)	66(1)
Subfamily Panurginae						
Tribe Calliopsini						
<i>Calliopsis</i>	3	1	1	1	1	1
Tribe Protandrenini						
<i>Pseudopanurgus</i>	15	4	2	1	1	1
Tribe Panurgini						
Subtribe Panurginina						
<i>Panurginus</i>	3	1	0	0	0	0
Subtribe Perditina						
<i>Perdita</i>	27	7	1	0	3	2
Family Melittidae						
Subfamily Melittinae						
Tribe Macropidini						
<i>Macropis</i>	4	3	3	0	3*	2
Tribe Melittini						
<i>Melitta</i>	3	1	1	0	0	1
Family Megachilidae						
Subfamily Megachilinae						
Tribe Anthidiini						
<i>Anthidiellum</i>	2	1	1	0	0	1
<i>Anthidium</i>	4(2)	2(2)	2(2)	1(1)	2(2)	2(2)
<i>Paranthidium</i>	1	1	1	0	0	1

Table 1. Continued.

Superfamily Apoidea: Clade Anthophila (Bees)						
	EUSA	NYS	SNY	BRF	NYC	Ithaca
<i>Stelis</i>	15	6	2	2	1	4
Tribe Osmiini						
<i>Chelostoma</i>	3(2)	3(2)	2(1)	0	1	3(2)
<i>Heriades</i>	3	3	1	1	2	1
<i>Hoplitis</i>	8(1)	6(1)	3	2	1	4
<i>Osmia</i>	30(4)	20(3)	12(3)	10(2)	5(3)	13(2)
Tribe Megachilini						
<i>Megachile</i>	43(5)	22(4)	17(2)	7(2)	16(4)	13(2)
<i>Coelioxys</i>	25	12	7	2	5	9
Family Apidae						
Subfamily Xylocopinae						
Tribe Xylocopini						
<i>Xylocopa</i>	2	1	1	1	1	1
Tribe Ceratinini						
<i>Ceratina</i>	4	3	3	2	3	3
Subfamily Nomadinae						
Tribe Nomadini						
<i>Nomada</i>	76	47	25	18	19	26
Tribe Ammobatoidini						
<i>Holcopasites</i>	3	2	1	0	0	2
Tribe Epeolini						
<i>Epeolus</i>	21	7	4	0	1	3
<i>Tricpeolus</i>	26	7	1	0	1	2
Subfamily Apinae						
Tribe Osirini						
<i>Epeoloides</i>	1	1*	1*	0	1*	0
Tribe Emphorini						
<i>Ptilothrix</i>	1	1	0	0	1	0
Tribe Eucerini						
<i>Eucera</i>	7	1	1	0	0	0
<i>Melissodes</i>	27	12	6	2	9	8
<i>Peponapis</i>	1	1	1	0	1	1
<i>Svastra</i>	5	1	0	0	1*	0
Tribe Anthophorini						
<i>Anthophora</i>	6(1)	4	3	1	3	3
<i>Habropoda</i>	1	1	0	0	0	0
Tribe Bombini						
<i>Bombus</i>	21	18	15	8	12	15
Tribe Apini						
<i>Apis</i>	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)
TOTALS:	743(22)	423(18)	269(13)	144(8)	210(15)	274(15)

### Colletidae

We collected only two species of *Colletes*, *C. compactus* and *C. simulans*, neither of which was numerous. This scarcity of individuals and species (vs. the nine known from southern NY; see Table 1) may reflect the low frequency with which *Colletes* is captured in bowls (S. Droege, T. Griswold, pers. comm.) and perhaps a scar-

city of appropriate sandy nest banks in the vicinity of the sampling sites. Absence of *Colletes inaequalis* Say in net-collected samples from early spring is surprising, as this is a conspicuous and locally abundant species across much of the northeastern USA and is often encountered as it collects pollen from maples (*Acer* spp.), which are numerous at BRF.

Our sample of *Hylaeus*, including small series of only two ubiquitous *Hylaeus* spp., *H. mesillae* and *H. modestus*, is also impoverished. At least four additional species are abundant in nearby Putnam County (JSA and P. Gambino, unpublished) and should occur at BRF.

### Halictidae

All three augochlorine species known from NY are numerous at BRF. The abundance of *Augochlora pura* in our samples probably reflects the local availability of rotting logs in which this species excavates its nests. The most abundant bee in our sample, *Augochlorella aurata* (1,222 individuals collected) is a eusocial, ground-nesting species that is numerous across most of eastern North America. Populations of this species from northeastern USA and southern Canada were known as *A. striata* (Provancher) prior to recent synonymy with *A. aurata* in Coelho's (2004) revision of *Augochlorella*.

The two most common species of *Agapostemon* in NY (*A. sericeus* and *A. virescens*) were collected, but two species present more locally in southern NY [*A. texanus* Cresson and *A. splendens* (Lepeletier)] were not found. Absence of *A. splendens* is not surprising, as this species seems to be associated with sandy nesting substrates.

The cleptoparasitic genus *Sphecodes* was represented by *S. galerus*, *S. levis*, *S. fattigi*, and *S. johnsonii*, the last two recorded for the first time in NY (JSA has also collected *S. johnsonii* in Fairfield County, Connecticut, new state record). Two additional *Sphecodes* species, *S. atlantis* Mitchell and *S. dichrous* Smith, not found at BRF were collected elsewhere in Orange County in 1962 (Tuxedo Park vicinity; AMNH).

Three *Halictus* species ubiquitous in the eastern United States were found in good numbers, but the more precinctive *H. parallelus* Say was not collected.

*Lasioglossum* sensu stricto was represented by *L. coriaceum* and *L. leucozonium* (regarded for the first time as exotic, see

below), both widely distributed across NY, and by two species, *L. acuminatum* and *L. fuscipenne*, restricted to eastern NY (e.g., absent from the Fingerlakes Region; see range maps in McGinley 1986).

Two widely distributed, pollen-generalist species of carinate *Lasioglossum* (*Evyllaes*) (sensu Michener 2000) were collected (*L. cinctipes* and *L. quebecense*) in addition to the more localized *L. (Evyllaes) nelumbonis*. The latter seems to be strongly associated with aquatic emergent flowers. In our study, numerous *L. nelumbonis* were collected in pan traps placed along a causeway bisecting Jim's Pond, in which grew abundant Nymphaeaceae (*Nymphaea odorata*). Museum label data suggest that *L. nelumbonis* may be a pollen-specialist of Nymphaeaceae and/or Nelumbonaceae, but direct observations of pollen collecting behavior by this species have not yet been made due to the difficulty of observing and collecting bees on aquatic vegetation.

*Lasioglossum* (*Dialictus*) individuals were, as expected, particularly abundant in our bowl samples. These were found to belong to 22 identified species (additional, poorly known species may be included among our undetermined metallic *Dialictus*; most males of this subgenus were not determined) including two socially parasitic species (*Paralictus* sensu Mitchell 1960) and two black, non-metallic *Dialictus* species (=noncarinate *Evyllaes*; see Michener 2000). Among the identified species of metallic, pollen-collecting *Dialictus* collected in BRF (i.e., *Dialictus* sensu Mitchell 1960) the wood-nesting species *L. coeruleum*, *L. cressonii*, and *L. oblongum* were each numerous. Other notable metallic, pollen-collecting *Dialictus* species include two species typical of northern forests (*L. nigroviride* and *L. versans*), a distinctive species often found in sand pits (*L. heterognathum*), and an infrequently recorded species (due in part to identification difficulties) previously known in NY from a few specimens collected in or near the lower Hudson River Valley (*L. cattellae*). Single

females of the two socially parasitic *Dialictus* species were collected, one of which, *L. michiganense*, has previously been recorded in the literature solely from Mitchell's (1960) unique holotype female, collected in Wayne County, Michigan, in 1940. Our single female specimen and another female collected 30 June 2004 at the inlet to Lake Myosotis, Edmund Niles Huyck Preserve, Rensselaerville, Albany County, NY, by JSA and C. J. Daley are the first records outside of Michigan. Despite a lack of published records, this species is probably widely distributed across the northeastern USA. It was recently found in Maryland (S. Droege, pers. comm.; new state record) and southern Ontario, Canada (L. Packer, pers. comm.; new Canadian record). The male of this species remains unknown. The female of *L. michiganense* possesses a conspicuous, inner, subapical mandibular tooth, whereas the mandibles of other parasitic female *L. (Dialictus)* are simple (i.e., lack an inner tooth) with elongate slender tips. The other socially parasitic *Dialictus* found at BRF, *L. cephalotes*, has recently been found in NYC in Central Park, Prospect Park (JSA, new records), and the Bronx (collected by P. Gambino).

### Andrenidae

Our BRF sample included 40 species of *Andrena* but is still far from complete, as an additional 32 species known from southern NY were not recorded. Our sample was rich in vernal species characteristic of northeastern forests such as *A. imitatrix* and *A. nivalis*. Species associated with blueberry were particularly well represented including the *Vaccinium* oligoleges (pollen specialists) *A. bradleyi* and *A. carolina*, and the polylectic *A. carlini* and *A. rufosignata*. The last species is abundant (but under-collected; cf. LaBerge 1980) in northern blueberry bogs, and evidently reaches the southern limits of its range at or near Black Rock Forest, as it is unknown from New York City, Long Island, and elsewhere along the mid-Atlantic coast.

The long malar space of *A. rufosignata*, in comparison to its likely sister species *Andrena mandibularis* (LaBerge 1980), may be an adaptation to collecting nectar from the bell-shaped corollas of *Vaccinium* species. Another oligolectic *Andrena* collected, *A. cornelli*, is now thought to be a *Rhododendron* specialist based on field observations by JSA in Virginia, label data for newly identified material in museum collections, and the widely spaced scopal hairs of this species that can be considered an adaptation that holds *Rhododendron* pollen connected by viscin threads (Ascher, unpublished; cf. LaBerge 1980). *Andrena violae*, an oligolectic of *Viola*, possesses elongate maxillary palpi used to extract nectar from its host. *Viola* is otherwise most often visited by long-tongued bees such as *Osmia* that are able to reach its concealed nectaries. *Andrena violae* is numerous across much of the eastern United States, excluding the colder areas of the northeast, but was previously known in NY solely from a single male collected at Van Natta's Dam, Six Mile Creek, Ithaca, Tompkins County, 2 May 1936 (specimen examined, CUIIC). This species was not represented among collections made on *Viola* at this site and elsewhere in the Fingerlakes Region by JSA during 1997–2002, so evidence of its persistence in NY at a new station of occurrence is welcome. Other oligolectic *Andrena* at BRF include *A. krigiana*, a specialist of *Krigia* (dwarf dandelion), and *A. fragilis*, a specialist of *Cornus* (*Soida*). Three *Andrena* specialists of *Solidago* and *Aster* (tribe Astereae) were found, *A. hirticincta*, *A. nubecula*, and *A. simplex* (but not its sister species, *A. placata* Mitchell, which has been collected recently in Putnam Co., NY), as was the panurgine Astereae specialist *Pseudopanurgus andre-noides* [we recognize genus *Pseudopanurgus* in the broad sense of Mitchell, 1960, including *Protandrena* (*Heterosarus*) and *P. (Pterosarus)* of Michener, 2000]. *Andrena arabis* is a specialist of Brassicaceae that may actually benefit from spread of in-



vative Garlic Mustard *Alliaria petiolata* (Bieb.) Cavara & Grande. Many species that regularly collect pollen from rosaceous trees and shrubs, and are known or suspected to be important pollinators of apples, were collected in good numbers, including *A. miserabilis*, *A. (Melandrena)* spp., and *A. (Trachandrena)* species. *Andrena (Trachandrena) nuda* was numerous at BRF, which is near the northern edge of its range in NY (see map in LaBerge 1973).

### Melittidae

Although a deliberate effort was expended to locate and collect from *Vaccinium stamineum*, the host plant of *Melitta eickworti* Snelling and Stage (1995), this recently described species was not recorded during our survey. However, it has been collected nearby in Putnam County by P. Gambino, as has *O. virga* Sandhouse, another poorly known oligolege of Ericaceae (see Cane et al. 1985; they recorded *O. virga*, as *O. "felti"*, collecting "surprisingly pure" loads of Deerberry pollen; this species also uses other ericaceous hosts, M. Arduser pers. comm.). No *Macropis* were collected in this study although their host plant *Lysimachia* was present.

### Megachilidae

Native megachilid species collected at BRF included the cleptoparasites *Stelis (Dolichostelis) louisae* (one female) and *Stelis (Stelis) nitida* (one female). The former is a colorfully marked parasite of native resin bees in subgenus *Megachile* (*Chelostomoides*), including *M. (C.) campanulae* (the likely host in NY and New England), which reaches its northern distributional limits in southern New York. *Stelis nitida* was described in 1878 from specimens collected in Canada and NY, but there have been few subsequent collections from eastern North America. It is most likely a northern and montane species that parasitizes *Osmia*, or possibly large *Hoplitis* species. Our sample of eight native *Osmia* species includes series of the forest-associ-

ated *O. bucephala* and *O. pumila*. We collected single specimens of three species that are scarce or absent in other recent collections from New York State, *O. collinsiae*, *O. felti*, and *O. inermis*. The last species, a probable oligolege of Ericaceae (M. S. Arduser, pers. comm.) previously unreported from NY, has also been identified among recent samples of bees from the Adirondacks (JSA and W. L. Romey, new record). Another *Osmia* species, *O. distincta*, has been found elsewhere in NY (e.g., South Hill Swamp, Ithaca, Tompkins County; and along the Hudson River) and in Pennsylvania to visit *Penstemon*, including *P. digitalis* Nutt. The tuft of curved hairs on the ocellar region of this species would seem to be an adaptation for collecting pollen from *Penstemon*, although *O. distincta* is apparently not a strict oligolege of this genus (M. Arduser, pers. comm.).

Our sample of native *Megachile* and associated *Coelioxys* cleptoparasites is impoverished, perhaps reflecting the inefficiency of bowl traps for capturing these strong-flying species (although Megachilini can be trapped in numbers in bowls of appropriate color, S. Droege, pers. comm.). The species captured are widely distributed and numerous across New York, excepting *M. montivaga*, which is known in the state from a few collections in southern NY (e.g., recently collected at Edmund Niles Huyck Preserve in Albany County). A report of this species from Ithaca (Leonard 1928) is based on a misidentified *M. inermis*.

### Apidae, excluding bumble bees

Large and small carpenter bees were represented respectively by *Xylocopa virginica* (locally very numerous at BRF, but most uncollected) and by two abundant sister species of *Ceratina (Zadoutomeris)*, *C. calcarata* and *C. dupla*, that cannot be distinguished in the females. The related *C. strema* Smith is also common in NY but was not collected.

All 18 identified species belonging to the *ruficornis* group of *Nomada* (= *Nomada s.str.*) in our samples are known or suspected to be cleptoparasites of *Andrena* species. Commonly encountered species of this group at BRF and other forested areas of the northeastern USA and southeastern Canada include the large, conspicuous species *N. luteoloides* (a valid species distinct from *N. sulphurata* Smith; see Schwarz and Gusenleitner 2004) and *N. maculata*, both cleptoparasites of large *Andrena* belonging to the subgenus *Melandrena* (Milickzy and Osgood 1995), and *N. bella*, a cleptoparasite of *A. imitatrix*. A new probable host association between *N. bella* and *A. imitatrix* was inferred by JSA (new information) based on repeated co-occurrence of these species at several sites across several years. Females of *N. bella* have been identified (M. Schwarz, pers. comm.) but remain undescribed. Further study of *Nomada* with bidentate mandibles (= *Gnathias* sensu Mitchell 1962) is needed to clarify separation of *N. bella* from *N. ovata*, *N. lepida*, and other similar species. We collected a single male *Nomada australis*, which is one of the three species belonging to the *erigeronis* group (= *Centrias*) known from NY. These are aestival cleptoparasites of *Agapostemon*.

*Anthophora* was represented by the wood-nesting species *A. (Clisodon) terminalis*, which is widely distributed and numerous in northern and montane forests from Siberia to eastern Canada [Davydova and Pesenko 2002; these authors distinguished the Holarctic *A. terminalis* from the Palearctic *A. furcata* (Panzer)].

### Bumble bees

Black Rock Forest is a favorable habitat for bumble bees, and certain species were found in large numbers, especially *Bombus (Pyrobombus) impatiens* and its social parasite *B. (Psithyrus) citrinus* (also known to attack other *Bombus* species). Large numbers of *B. impatiens* in our late season samples reflect the unusually large colony

size and long flight season (JSA has observed males flying as late as November 10 in Ithaca, NY, a colder locality than BRF) characteristic of this species. Other bumble bee species encountered include *B. perplexus* and *B. vagans*, both generally numerous in New York forests and bogs, and the widely distributed *B. bimaculatus* and *B. griseocollis*. We found few *B. vagans*, but the extremely similar (and thus infrequently identified) *B. sandersoni* was found in surprisingly large numbers, including series of queens, males, and workers. Two *Bombus ternarius* were found. This is a species of northern affinities found commonly south to the Catskills. Leonard (1928:1031–1032) regarded it as, "Essentially a Canadian and northern transition species...", and stated that "the species is not found near NYC. (Beq) [indicating J. Bequaert as the source]." Long-tongued bumble bee species belonging to subgenera *Fervidobombus* [*B. fervidus* (Fabricius) and *B. pensylvanicus* (Degeer)] and *Subterraneobombus* (*B. borealis* Kirby) that frequently visit clovers (especially *Trifolium*) were not collected. Absence of *B. fervidus* is surprising, but *B. pensylvanicus* has been scarce in NY in recent years and is no longer, "An abundant southern species, common as far north as central NY..." (Leonard 1928:1032). *Bombus borealis* has always been uncommon in New York State (Leonard 1928), and is generally absent from developed areas (e.g., it is unknown from the city of Ithaca, NY, but occurs in nearby countryside).

Absence of *Bombus (Bombus) affinis* in our sample of 1261+ bumble bee individuals is troubling because this species is well represented in historical collections from the northeastern United States, and is expected to be "...moderately abundant in the eastern to southern parts of the [New York] State..." (Leonard 1928: 1031). However, this species has recently disappeared from New York (e.g., from Ithaca and the NYC area, JSA, unpublished) and elsewhere (L. Day, pers. comm.). The regional

disappearance of *B. affinis* is coincident with an abrupt decline in *B. (Bombus) terricola* Kirby at Ithaca NY (Ascher, unpublished), and elsewhere (L. Day, pers. comm.), as well as the extirpation of the closely related *B. (Bombus) occidentalis* Greene from the San Francisco Bay Area and elsewhere in western North America, and the precipitous decline of the endangered *B. (Bombus) franklini* from its exceptionally restricted range in southern Oregon and northern California (Thorpe 2005). Populations of *B. affinis*, and of all North American species of subgenus *Bombus*, and their obligate social parasites [e.g., *B. (Psithyrus) ashtoni*; a queen of this species was collected at BRF on June 13 1988, by J. G. Rozen], should be carefully monitored, as parasitism by *Nosema* and other parasites introduced and spread via the greenhouse trade in *Bombus* colonies poses a potentially severe threat to their survival.

*Introduced bee species.*—Our samples included numerous individuals of certain exotic bee species that have become established and locally invasive in eastern North America beginning in the 1990's.

*Megachile sculpturalis*, a giant resin bee native to northeastern Asia, was first collected in New York State in 1997 (Ascher 2001) and is now widely distributed and locally abundant in the Fingerlakes Region, and in southern NY, including NYC. Outside of New York, *M. sculpturalis* is now quite widely distributed and has recently been found in additional northeastern states such as Massachusetts (Martha's Vineyard, P. Gambino pers. comm.), Vermont, and New Hampshire (S. Droege, pers. comm.), as predicted by Hinojosa-Díaz et al. (2005).

The horn-faced mason bee *Osmia cornifrons*, native to eastern Asia including Japan, was deliberately introduced by USDA scientists as a managed pollinator of apples. After wide distribution and release, this species has recently established large populations in natural and urban (e.g., Manhattan and Brooklyn,

NYC) habitats in the eastern United States to the point where it could be classified as invasive. We collected 66 specimens from on or around native vegetation and in bowls, and one female emerged from a trap nest. Non-specificity to orchards should not be surprising as *Osmia (Osmia)* species such as *O. cornifrons* and the closely related native species *O. lignaria* are polylectic, not specialists of fruit crops. In areas near where *O. cornifrons* were deliberately released (e.g., Patuxent National Wildlife Refuge, see Cane 2003), a very similar Asian species, *Osmia (Osmia) taurus* Smith has been found to be established. This species has also been found in Huntingdon County in south-central Pennsylvania (VG, new data), but not yet in NY.

We collected 10 *Anthidium oblongatum*, a species native to Europe and only recently detected in North America (Hoebcke and Wheeler 1999). This species is now abundant in the mid-Atlantic States, New York, and southern New England, usually in association with favored host plants such as *Lotus corniculata*, a weed generally distributed in waste places such as roadsides and abandoned lots, and *Sedum*.

The halictine species *Lasioglossum (L.) leucozonium* has long been present in North America and has therefore been generally regarded as native. However, its North American range is restricted to northeastern USA and southeastern Canada and does not include northwestern Canada or Alaska (see maps in McGinley 1986). This distributional pattern, and association of this species with introduced weeds such as *Chicorium* (Asteraceae), suggests that this ground-nesting species is adventive from Europe, not native as has been assumed. Molecular phylogenetic placement of *L. leucozonium* and *L. zomilum* (Smith) within the otherwise exclusively Old World *leucozonium* species group, and lack of significant genetic differences between Old and New World samples (see, e.g., Danforth and Ji 2001), further support the idea that the occurrence of these species in North

America is adventive. It is possible that these species were introduced in soil carried in ships' ballast as has been hypothesized for another ground-nesting bee species native to Europe and found in our study, *Andrena wilkella*. Extensive sampling of variable molecular markers such as COI is needed to test hypotheses of native vs. adventive origin for bee species with Holarctic distributions. *Megachile centuncularis* (L.) may be another early introduction from Europe, as this species has not been recorded in Alaska as would be expected for a species with a naturally Holarctic range.

Workers of *Apis mellifera* (L.) were abundant from mid-June and into October but were generally not collected.

Of the 144 bee species recorded in this study, six (4.2%) are exotic and 138 (95.8%) are native. Of the 6,543 specimens collected, 115 (1.7%) belong to exotic species, and 6,428 (98.2%) belong to native species.

*Wasps and other non-bees.*—Our apoid wasp samples include 23 crabronid species (12 genera; Appendix 2). Some of these are generally numerous in forest edge habitats in New York such as *Ectemnius continuus*, which nests in holes in wood. Other species collected such as *Astata leuthostromi* and *Bicyrtes quadrifasciata* are ground-nesters that favor more open, often sandy habitats. Our vespidae sample includes long series of the native paper wasp *Polistes fuscatus*, both sexes of *Vespula consobrina*, a yellowjacket of northern (Canadian and Transition Zones) affinities, one individual of the rather scarce *Zethus spinipes*, and a variety of eumenines including cavity-nesting species found in our trap nests.

*Ecological and behavioral patterns.*—Ecological information (summarized in Appendix 1) was compiled for each of the 144 bee species from information found in catalogs and revisions, primary literature, and field observations, including those made during the BRF survey.

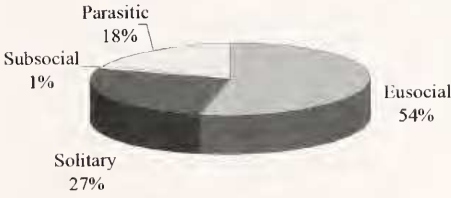
Of the 6,543 specimens collected, 5,364 (82.0%) belong to pollen collecting species,

and 1,179 specimens (18.2%) belong to parasitic species (Fig. 1a). Of the 144 bee species recorded in this study, 116 (80.5%) are pollen-collecting species and 28 (19.4%) are parasitic (Fig. 1b). The abundance and diversity of parasites reflects a rich fauna of vernal *Nomada* associated with *Andrena* hosts. The preponderance of females (4321 vs. 1977 males vs. 245 of unrecorded sex) corresponds with the large number of workers of eusocial species, including the two most numerous species at BRF. Of the 6,543 bee specimens collected, 1,222 (18.7%) were *Augochlorella aurata* and 845 (12.9%) were *Bombus impatiens*. The sample of 1,113 bumble bees collected was dominated by *B. impatiens* (845, 75.9%) and its social parasite *B. (Psithyrus) citrinus* (154, 14.1%).

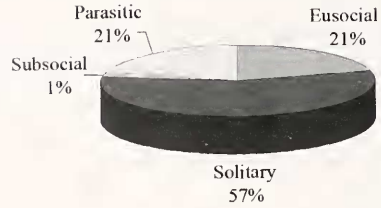
Seasonal patterns of occurrence can be obtained from Appendix 1, which gives extreme dates for BRF (by calendar date), NY as a whole (by month), and the entire North American range (by month) for each species. General patterns include an abundance and diversity of *Andrena* and their *Nomada* parasites at forest floor sites prior to leaf-out. At more open sites, seasonal turnover of the bee fauna was apparent, with notable peaks of abundance and species diversity corresponding with the bloom of favored plants such as *Vaccinium* in late spring (visited by, e.g., *Andrena* and *Osmia* spp.) and *Solidago* in late summer (visited by, e.g., *Colletes* spp., *Andrena simplex*, *Pseudopanurgus andreoides*, and the workers and males of the dominant eusocial species *Augochlorella aurata* and *Bombus impatiens*). Rather few oligolectic bee individuals were captured (292, 4.5% of the total) (Fig. 2a), but these represented a significant number of species in our sample (19, 13.2%) (Fig. 2b).

Although soil nesting individuals and species predominated in our samples, hive nesters, wood burrowers, and cavity-nesters were also well represented (Fig. 3a, b). Cavity-nesting species were numerous relative to the number of individuals, as

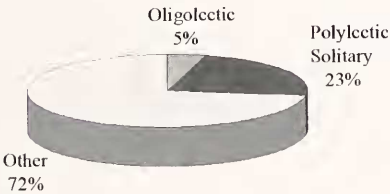
**1A Sociality of Individuals**



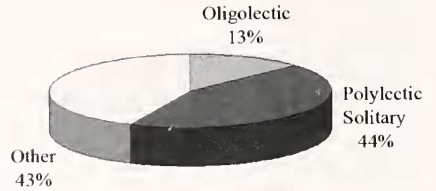
**1B Sociality of Species**



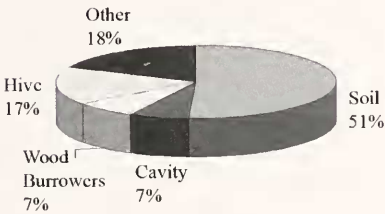
**2A Oligolectic vs. Polylectic Individuals**



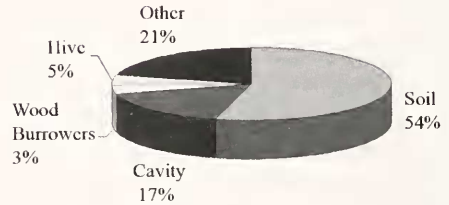
**2B Oligolectic vs. Polylectic Species**



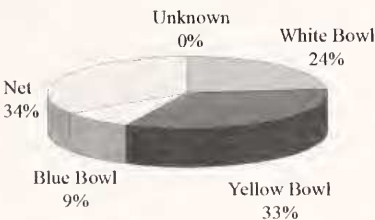
**3A Nest Substrate by Individuals**



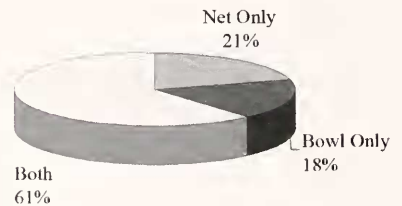
**3B Nest Substrate by Species**



**4A Net and Bowl Catch by Individuals**



**4B Species Catch by Method**



Figs 1-4. Summary of ecological properties of Black Rock Forest (BRF) bees. 1, Sociality. The category "solitary" includes communal species. Some individual nests or local populations of species categorized as "eusocial" may be solitary: 1A, percentage of individual bees belonging to each of the four recognized categories of sociality; 1B, percentage of bee species belonging to each of the categories. 2, Pollen specialization; those classified as oligolectic are specialists that usually collect pollen from only a single family of plants; the polylectic category includes polylectic solitary bees only; those in the "other" category include parasites and social bees, which are necessarily generalists (i.e. polylectic): 2A, percentage of bee individuals that are

several cavity-nesters were represented by singletons or doubletons. By contrast, wood burrowing species were relatively few (Fig. 3b), although some of these species were captured in large numbers (e.g., *Augochlora pura*). The large number of hive-nesting individuals relative to species likely reflects their eusociality (see above).

A few species typical of more open and sandy areas were found at BRF (e.g., *Lasioglossum heterognathum*, *Bicyrtes*, *As-tata*), but sand specialists such as *L. vierecki* were not found.

*Efficacy and Biases of trapping methods.*—The year 2003 was characterized by long periods of cold and cloudy weather and pans may have been particularly useful under these conditions as these allow catch during brief windows of sun on days when net-collecting would be unrewarding. Nearly twice as many individuals were bowl trapped than netted (4,322 vs. 2,221) (Fig. 4a), but the net sample was biased against certain of the most common and readily identified taxa (see above). Bowls were found to be particularly useful in forest and at the forest edge where flowers are few, dispersed, or in the case of trees and shrubs, difficult to reach. Where flowers are scarce, bowls may be particularly effective due to lack of competition from real flowers. Using bowls, we found certain inconspicuous forest-associated species rarely taken in nets such as *Stelis nitida*. Well known biases of bowl traps reinforced by our study include low catch rates for certain groups, especially fast and high-flying species of, e.g., *Colletes*, *Megachile*, and perhaps *Melissodes*, and high catch rates for

slow and low-flying species of, e.g., small *Lasioglossum*, *Andrena*, *Osmia*, and *Nomada*. Our results generally support the currently accepted view that a combination of bowl trapping using multiple colors and netting is the best way to efficiently collect a plurality of species (S. Droege et al. protocol). Only 89 of the 144 bee species collected (61.8%) were collected by both nets and bowls, with 30 species (20.8%) unique to nets and 26 (17.6%) unique to bowls (Fig. 4b). The net collected sample was richer than the bowl trapped sample in total bee species (117 vs. 113) and in number of unique species (29, 20.4% vs. 25, 17.6%).

Although wood and cavity-nesting bees were numerous in this survey, only one individual bee (the introduced *Osmia cornifrons*) used our trap-nests. The poor performance of trap-nests might possibly be explained by an abundance of natural nesting substrates (standing dead wood) at BRF. Alternatively, bees may have been out-competed for the trap-nests by eumenes and *Trypoxylon*, or else the nests may have been placed in sites that ultimately proved to be too shady.

*Comparison to other bee faunas.*—In comparison to the bee fauna of NYS as a whole (423 species) and to the fauna of some well-sampled localities within the state such as Ithaca (274 species), the 144 species identified in our BRF sample is relatively few (Table 1). However, several of these records are of considerable biogeographic or ecological interest (see above). The NY bee fauna includes many species which are regionally rare and/or have highly specialized ecological requirements, and are therefore unlikely to be found at BRF.

---

←  
oligolectic, polylectic and solitary, or other; 2B, percentage of bee species that are oligolectic, polylectic and solitary, or other. 3, Nest substrates: 3A, percentage of individuals belonging to each nesting category: soil, cavity, wood burrowers, hive, or other (primarily cleptoparasites that live in the nests of their hosts); 3B, percentage of bee species known or inferred to use the nest substrate indicated. 4, Collecting method: net vs. white bowl, vs. blue bowl, vs. yellow bowl: 4A, percentage of bee individuals caught by each method; 4B, percentage of bee species caught by net only vs. bowl only vs. both net and bowl.

Nonetheless, it seems highly probable that at least 250 bee species could be present at BRF based on totals of 274 species recorded from Ithaca, Tompkins County, NY (Ascher, unpublished), in a colder climate than BRF, and ca. 300 species recorded from the vicinity of Carlinville in southern Illinois (Robertson 1929, Marlin and LaBerge 2001), in seemingly unremarkable farm country.

The high number and proportion of singletons (28 spp., 19.4%), of doubletons (12 spp., 8.3%), of species known from a single sex (ca. 31 spp., ca. 21.0%) excluding *Lasioglossum*, and of rarely collected species (i.e., 3–10 individuals collected: 36 species, 25.3%), indicate that more prolonged and intensive surveying using the same methods would reveal many additional species, likely resulting in taxonomically and biogeographically significant specimens.

Another indication of the incompleteness of sampling of the total BRF fauna is that only 57.8% of the 249 bee species known from southern New York excluding NYC and Long Island (i.e., Sullivan, Ulster, and Dutchess, Orange, Putnam, Rockland, and Westchester, Counties) were found. These might be considered to represent a regional pool of species from an area relevant to BRF. The total of 249 species known from an area relevant to BRF is only 59% of the species total for New York State as a whole (423), which in turn is only 57% of the 743 bee species known from the eastern USA. Twenty additional species recorded in NY only from coastal NYC and Long Island (e.g., the coastal dune specialist *Lasioglossum marinum*) are less likely to occur at BRF.

Most bee species at BRF are widely distributed in NY and have been recorded from other well-collected sites such as Ithaca (123 species shared with BRF, 85.4% of the BRF total) and NYC (103 species shared with BRF, 71.5% of the BRF total). Northern elements of the fauna at BRF can be defined as those species known

from the northern and montane portions of NY (e.g., the Adirondack Mountains and in most cases Ithaca), but absent from NYC, Long Island, and other warmer and coastal areas. Examples of northern species occurring at or near their southern limits at BRF and unknown from NYC include *Andrena rufosignata*, *A. algida*, *Stelis nitida*, *Osmia felti*, *O. inermis*, *Bombus ternarius*, and possibly *B. sandersoni* (southern distributional limits of this species remain uncertain due to identification difficulties versus *B. vagans*). Although these northern species are likely genuinely absent from NYC, many of the 42 species known from BRF, but not NYC may be found in the latter area when more thorough samples have been made of semi-natural habitats such as Pelham Bay Park. Southern elements in the BRF fauna include the following species that are unknown from the very well collected Fingerlakes Region (which includes Ithaca): *Lasioglossum bruneri*, *Andrena nuda*, *A. confederata*, *A. hilaris*, and *Melissodes subillata*. The apparent absence of these species from Ithaca and elsewhere in central and northern New York is probably genuine and likely reflects a real faunal difference from BRF. *Andrena violae* is another species of southern affinities that is very rare in Ithaca (see above).

The Sørensen index [ $C_s = 2a/(2a + b + c)$  where  $a$  is the number of species shared between two sites,  $b$  is the number of species found at only one site, and  $c$  is the number of species found only at the other site] was used to quantify similarity between various sites. The total for BRF vs. Ithaca is 58.9% whereas the total for BRF vs. NYC is 58.2%. The similar Sørensen values for comparisons involving these two areas (despite BRF's much greater geographical proximity to NYC) reflect many shared widespread and northern species with Ithaca, and significant differences between BRF and NYC due to the presence of northern forest elements (e.g., blueberry associates) only at BRF and of coastal/sand associates only in NYC.

## ACKNOWLEDGMENTS

We are grateful to the staff of Black Rock Forest for their invaluable advice and assistance with practical matters, and to the Steifel Foundation for an award from their Black Rock Forest Consortium Small Grants for Scientific Research and Education program awarded to J.G. Rozen and V. Giles. We thank: S. Droege, L. Day, and T. Griswold for identifying bees, and M. Arduser for sharing unpublished keys and other taxonomic information and commenting on the manuscript. P. Gambino provided unpublished records of NY bees and identified many of our crabronid wasps. K. Magnacca provided bee records and other assistance. The following people kindly provided access to and information about historical collections of New York bees: B. N. Danforth, E. R. Hoebeke, J. K. Liebherr, T. McCabe, T. Schultz, D. Yanega. S. Kornbluth generously provided assistance with specimen labeling and data entry and management. We thank K. Russell for her helpful discussions of methods and data base management. C. Encarnacion, and E. Burbano prepared our specimens. T. Nguyen lent his assistance with technical matters. J. G. Rozen, J. M. Carpenter, A. C. Vallely, and C. Dong made valuable comments on this manuscript. J. M. Carpenter identified our vespid wasps. We thank R. G. Goelet for his support of bee research at the AMNH. We are especially grateful to J.G. Rozen for his guidance and support. In addition to his help in this project, we both owe our interest in bees to his generosity and encouragement.

## LITERATURE CITED

- Ascher, J. S. 2001. *Hylaeus hyalinatus* Smith, a European bee new to North America, with notes on other adventive bees (Hymenoptera: Apoidea). *Proceedings of the Entomological Society of Washington* 103: 184–190.
- Barringer, K. and S. E. Clemants. 2003. The vascular flora of Black Rock Forest, Cornwall, New York. *Journal of the Torrey Botanical Society* 130: 292–308.
- Cane, J. H. 2003. Exotic nonsocial bees (Hymenoptera: Apiformes) in North America: Ecological implications. Pp. 113–126 in: Strickler, K. and J. H. Cane, eds. *For Non-native Crops, Whence Pollinators of the Future*. Thomas Say Publications in Entomology: Proceedings.
- Cane, J. H. 2005. Bees, pollination, and the challenges of sprawl. Pp. 109–124 in: E. A. Johnson and M. W. Klemens, eds. *Nature in Fragments: the Legacy of Sprawl*. Columbia University Press.
- Cane, J. H., G. C. Eickwort, F. R. Wesley, and J. Spielholz. 1985. Pollination ecology of *Vaccinium stamineum* (Ericaceae: Vaccinoideae). *American Journal of Botany* 72: 135–142.
- Cane, J. H. and V. J. Tepedino. 2001. Causes and extent of declines among native North American pollinators: detection, evidence, and consequences. *Conservation Ecology* 5: art. 1 [online].
- Coelho, B. W. T. 2004. A review of the bee genus *Augochlora* (Hymenoptera: Halictidae: Augochlorini). *Systematic Entomology* 29: 282–323(42).
- Danforth, B. N. and S. Ji. 2001. Australian *Lasioglossum* + *Homalictus* form a monophyletic group: Resolving the "Australian enigma". *Systematic Biology* 50: 268–283.
- Davydova, N. G. and Yu. A. Pesenko. 2002. Bees of the subgenus *Clisodon* (Anthophora, Hymenoptera, Apidae) in the fauna of Russia. *Entomological Review* 82: 621–624. [translated from *Zoologicheskii Zhurnal* 81(11)]
- Hinojosa-Díaz, I. A., O. Yáñez-Ordóñez, G. Chen, A. T. Peterson, and M. S. Engel. 2005. The North American invasion of the giant resin bee (Hymenoptera: Megachilidae). *Journal of Hymenoptera Research* 14: 69–77.
- Hoebeke, E. R. and A. G. Wheeler, Jr. 1999. *Anthidium oblongatum* (Illiger): an Old World bee (Hymenoptera: Megachilidae) new to North America, and new North American records for another adventive species, *A. manicatum* (L.). *The University of Kansas Natural History Museum Special Publication* 24: 21–24.
- Hurd, P. D., Jr. 1979. Superfamily Apoidea. Pp. 1741–2209 in: K. V. Krombein, P. D. Hurd, Jr., D. R. Smith, and B. D. Burks, eds. *Catalog of Hymenoptera of America north of Mexico, vol. 2*. Smithsonian Institution Press, Washington, D. C.
- LaBerge. 1973. A revision of the bees of the genus *Andrena* of the Western Hemisphere, Part VI: Subgenus *Trachandrena*. *Transactions of the American Entomological Society* 99: 235–371.
- LaBerge. 1980. A revision of the bees of the genus *Andrena* of the Western Hemisphere, Part X: Subgenus *Andrena*. *Transactions of the American Entomological Society* 106: 595–525.
- Leonard, M. D. 1928. A list of the insects of New York, with a list of the spiders and certain other allied groups. *Cornell University Agricultural Experiment Station Memoir* 101: 5–1121.
- Marlin, J. C. and W. E. LaBerge. 2001. The native bee fauna of Carlinville, Illinois, revisited after 75 years: a case for persistence. *Conservation Ecology* 5: art. 9. [online]
- Matheson, A., S. L. Buchmann, C. O'Toole, P. Westrich, and I. Williams, eds. 1996. *The Conservation of Bees*. *Linnaean Society Symposium Series*, Number 11. Academic Press, London.
- McGinley, R. J. 1986. Studies of Halictinae (Apoidea: Halictidae), I: Revision of New World *Lasioglossum* Curtis. *Smithsonian Contributions to Zoology*, no. 429: 294 pp.
- Michener, C. D. 2000. *The Bees of the World*. The Johns Hopkins University Press, Baltimore, Maryland.
- Miliczky, E. R. and E. A. Osgood. 1995. Bionomics of *Andrena* (*Melandrena*) *vicina* Smith in Maine and



- Washington, with new parasite records for *A. (M.) regularis* Malloch and a review of *Melandrena* biology. *Journal of the Kansas Entomological Society* 68: 51–66.
- Mitchell, T. B. 1960. *Bees of the eastern United States, Vol. 1. North Carolina Agricultural Experimental Station Technical Bulletin.*
- Mitchell, T. B. 1962. *Bees of the eastern United States, Vol. 1. North Carolina Agricultural Experimental Station Technical Bulletin.*
- Nilsson, L. A. 2000. Critical resource levels for viable wild bee populations. [www.cbm.slu.se/forskning/naturvardskedjan/pdf/wildbee.pdf](http://www.cbm.slu.se/forskning/naturvardskedjan/pdf/wildbee.pdf)
- Robertson. 1928. *Flowers and Insects. Lists of visitors of four hundred and fifty-three flowers.* Carlinville, Illinois: Published by the author.
- Schwarz, M. and F. Gusenleitner. 2004. Beitrag zur Klärung und Kenntnis parasitärer Bienen der Gattungen *Coelioxys* and *Nomada* (Hymenoptera, Apidae). *Linzer biologische Beiträge* 62: 1413–1485.
- Snelling, R. R. and G. I. Stage. 1995. A revision of the Nearctic Melittidae: The subfamily Melittinae (Hymenoptera: Apoidea). *Natural History Museum of Los Angeles County Contributions in Science* No. 451: 1–17.
- Thorp, R. W. 2005. Species profile: *Bombus franklini*. In: Shepherd, M. D., D. M. Vaughan, and S. H. Black, eds. *Red List of Pollinator Insects of North America*. CD-ROM Version 1 (May 2005). The Xerces Society for Invertebrate Conservation, Portland, OR.
- Williams, N. M., R. L. Minckley, and F. A. Silveira. 2001. Variation in native bee faunas and implications for detecting community changes. *Conservation Ecology* 5: art. 7. [online]

Appendix 1. List of bee species collected at Black Rock Forest (BRF) in 2003. For family-group classification see Table 1. **BRF individuals**, the total number of individual bees recorded during the survey. Individual totals for certain *Nomada*, *Sphacodes*, and *Bombus* species may be imprecise as not all specimens could be determined with certainty. The notation [++] after *Xylocopa virginica* and *Apis mellifera* indicate that numerous additional individuals of these species were seen at BRF but not collected; the notation [+] indicates that we do not regard these *Nomada* species as singletons or doubletons as additional specimens of these species likely exist among the remaining undetermined specimens. **BRF flight period**, The first and last dates on which specimens were collected at BRF in 2003. **NY flight period**, The recorded flight period by month across the entire Nearctic range of the species. Certain anomalous records, such as late summer records for typical spring species, may be erroneous and have been omitted from the totals. **NY abundance**, Perceived abundance in NY as a whole for each species found at BRF based on all available collections. In descending order: A = abundant, C = common, F = fairly common, U = uncommon, R = rare. Although subjective, these provide some context for the BRF records. Some species may prove to be more abundant than indicated when improved samples and identification tools become available. Some species indicated as uncommon or rare in New York, such as *Andrena violae*, are numerous in other states. **Native vs. exotic**, Each species is classified as native (N) or exotic (E) based on current and historical patterns of distribution. **Nest substrate**, The known or inferred nest substrate of each non-parasitic species is categorized as either soil (S), cavity (C), usually pre-existing, often in wood or pith, typically above-ground), wood burrowing (W; typically in rotting or soft wood); and hive (H). *Xylocopa virginica* (not placed in a category) burrows in hard wood. The nest sites of many species remain unknown but can be inferred based on nest substrates used by closely related species. **Sociality**, Each species is characterized as solitary (S), subsocial (B), eusocial (E), or parasitic (P). The behavior of many species remains unstudied but can be inferred based on the known behavior of closely related species. **Pollen specificity**, Each solitary, pollen-collecting species has been characterized as either oligolectic (pollen specialist; usually collecting pollen from flowers belonging to a single plant family) or polylectic (pollen generalist; regularly collecting pollen from more than one plant family). **New York**, An X indicates a verified record for New York City (i.e. the five boroughs). **Ithaca**, An X indicates a verified record within the city limits of Ithaca, Tompkins County.

Species	BRF individuals	BRF flight period	NY flight period	Nearctic flight period	NY abundance	Native vs. Exotic	Nest Substrate	Sociality	Pollen specificity	New York City	Ithaca
<i>Colletes compactus</i> Cresson, 1868	3	Sep 30-Oct 16	8-10	7-11	C	N	S	S	O	X	X
<i>Colletes simulans</i> Cresson, 1868	1	Aug 28	7-10	1, 5-11	A	N	S	S	O	X	X
<i>Hylaeus (Hylaeus) mesillae</i> (Cockerell, 1896)	1	Aug 14	4-9	4-10	C	N	C	S	P	X	X
* <i>Hylaeus (Prosopis) modestus</i> Say, 1837	19	May 27-Sept 11	5-9	5-9	A	N	C	S	P	X	X
<i>Hylaeus (Prosopis) modestus</i> Say females [or <i>affinis</i> (Smith)]	125	June 24-Sept 29									
<i>Augochloropsis (Paraugochloropsis) metallica</i> (Fabricius, 1793)	23	June 10-Oct 1	5-10	3-11	C	N	S	S	P	X	X
<i>Augochlorella aurata</i> (Smith, 1853)	1222	April 24-Oct 1	4-10	4-10	A	N	S	E	-	X	X
<i>Augochlora (Augochlora) pura</i> (Say, 1837)	289	May 5-Oct 16	4-10	4-10	A	N	W	S	P	X	X
<i>Agapostemon (Agapostemon) sericeus</i> (Förster, 1771)	2	Aug 15-Sept 6	4-10	4-10	C	N	S	S	P	X	X
<i>Agapostemon (Agapostemon) virescens</i> (Fabricius, 1775)	7	May 9-Oct 1	5-10	5-10	C	N	S	S	P	X	X
<i>Sphacodes johnsonii</i> Lovell, 1909	2	Aug 14	8-10	8-10	U	N	-	P	-	X	X

Appendix 1. Continued.

Species	BRF individuals	BRF flight period	NY flight period	Nearctic flight period	NY abundance	Native vs. Exotic	Nest Substrate	Sociality	Pollen specificity	New York City	Thaca
<i>Sphex faticgi</i> Mitchell, 1956	3	Aug 15	8	8-10	R	N	-	P	-		
<i>Sphex galerus</i> Lovell & Cockerell, 1907	1	June 24	4-8	4-9	F	N	-	P	-	X	X
<i>Sphex levis</i> Lovell & Cockerell, 1907	1	May 18	5-8	5-8	U	N	-	P	-	X	X
<i>Halictus (Odontalictus) ligatus</i> Say, 1837	229	May 9-Oct 16	4-10	1-12	A	N	S	E	-	X	X
<i>Halictus (Protahalictus) rubicundus</i> (Christ, 1791)	4	May 18-July 26	3-9	3-9	C	N	S	E	-	X	X
<i>Halictus (Seladonia) confusus</i> Smith, 1853	39	May 18-Oct 1	4-10	4-10	A	N	S	E	-	X	X
<i>Lasioglossum (Lasioglossum) acuminatum</i> McGinley, 1986	2	May 9-June 10	5-7	4-10	F	N	S	S	P	X	X
<i>Lasioglossum (Lasioglossum) coriaceum</i> (Smith, 1853)	1	Sept 6	4-9	3-10	A	N	S	S	P	X	X
<i>Lasioglossum (Lasioglossum) fuscipenne</i> (Smith, 1853)	1	July 8	5-10	3-12	F	N	S	S	P	X	X
<i>Lasioglossum (Lasioglossum) leucozonium</i> (Schränk, 1781)	8	May 18-Sept 29	5-10	5-10	A	E	S	S	P	X	X
<i>Lasioglossum (Erylaeus) cinctipes</i> (Provancher, 1888)	4	June 24-July 26	4-9	3-9	C	N	S	E	-		X
<i>Lasioglossum (Erylaeus) nelumbonis</i> (Robertson, 1890)	21	July 8-Oct 1	6-9	3-11	F	N	S	S	O	X	X
<i>Lasioglossum (Erylaeus) quebecense</i> (Crawford, 1907)	14	April 24-Aug 28	3-9	3-9	C	N	S	S	P	X	X
<i>Lasioglossum (Dialictus) abanci</i> (Crawford, 1932)	181	April 24-Sept 11	4-8	4-9	C	N	S	E	-	X	X
<i>Lasioglossum (Dialictus) admirandum</i> (Sandhouse, 1924)	24	May 9-Oct 1	4-9	3-9	A	N	S	E	-	X	X
<i>Lasioglossum (Dialictus) albipenne</i> (Robertson, 1890)	1	Sept 11	5-9	5-9	C	N	S	E	-	X	X
<i>Lasioglossum (Dialictus) bruneri</i> (Crawford, 1902)	24	May 9-Sept 11	4-10	2-10	C	N	S	E	-		
<i>Lasioglossum (Dialictus) cattellae</i> (Ellis, 1913)	9	May 9-Sept 11	5-9	5-9	F	N	S	E	-		
<i>Lasioglossum (Dialictus) cephalotes</i> (Dalla Torre, 1896)	1	May 5	5-9	5	U	N	-	P	-	X	X
<i>Lasioglossum (Dialictus) coeruleum</i> (Robertson, 1893)	21	May 18-Sept 11	4-9	4-10	C	N	W	E	-	X	X
<i>Lasioglossum (Dialictus) cressonii</i> (Robertson, 1890)	58	April 24-Sept 11	4-9	3-10	C	N	W	E	-	X	X
<i>Lasioglossum (Dialictus) divergens</i> (Lovell, 1905)	1	July 8	6-7	6-7	C	N	S	S	P	X	X
<i>Lasioglossum (Dialictus) foxii</i> (Robertson, 1895)	59	April 16-July 8	4-7	4-9	C	N	S	S	P	X	X
<i>Lasioglossum (Dialictus) heterognathum</i> (Mitchell, 1960)	6	May 18-Sept 6	5-9	4-9	C	N	S	E	-	X	X
<i>Lasioglossum (Dialictus) imitatum</i> (Smith, 1853)	13	May 18-Oct 1	4-10	4-10	A	N	S	E	-	X	X
<i>Lasioglossum (Dialictus) laevissimum</i> (Smith, 1853)	20	May 9-Sept 21	3-9	3-10	C	N	S	E	-	X	X
<i>Lasioglossum (Dialictus) lineatum</i> (Crawford, 1906)	53	April 24-Oct 1	4-10	4-10	A	N	S	E	-	X	X
<i>Lasioglossum (Dialictus) lineatum/roliveri</i>	28	April 16-Aug 15									
<i>Lasioglossum (Dialictus) michiganense</i> (Mitchell, 1960)	1	Sept 29	6-9	6-9	R	N	-	P	-		

Appendix 1. Continued.

Species	BRF individuals	BRF flight period	NY flight period	Nearctic flight period	NY abundance	Native vs. Exotic	Nest Substrate	Sociality	Pollen specificity	New York City	Ithaca
<i>Lasiglossum (Dialictus) nigroviride</i> (Graenicher, 1911)	3	Aug 28	4-8	4-10	C	N	S	E	-	X	X
<i>Lasiglossum (Dialictus) nymphacarum</i> (Robertson, 1895)	1	Aug 28	4-10	4-10	C	N	S	E	-	X	X
<i>Lasiglossum (Dialictus) oblongum</i> (Lovell, 1905)	102	May 9-Oct 1	4-9	3-10	C	N	W	E	-	X	X
<i>Lasiglossum (Dialictus) pilosum</i> (Smith, 1853)	1	July 8	4-10	2-10	A	N	S	E	-	X	X
<i>Lasiglossum (Dialictus) rohweri</i> (Ellis, 1915)	213	April 24-Sept 29	4-9	4-9	A	N	S	E	-	X	X
<i>Lasiglossum (Dialictus) tegulare</i> (Robertson, 1890)	169	May 9-Sept 29	4-10	1-12	C	N	S	E	-	X	X
<i>Lasiglossum (Dialictus) versans</i> (Lovell, 1905)	4	June 2-Sept 11	4-9	4-10	C	N	S	E	-	X	X
<i>Lasiglossum (Dialictus) undet.</i>	188	April 24-Oct 1									
<i>Andrena (Andrena) carolina</i> Viereck, 1909	113	May 5-June 24	5-6	4-7	C	N	S	S	O	X	X
<i>Andrena (Andrena) cornelli</i> Viereck, 1907	1	May 27-Sept 11	5-6	4-7	U	N	S	S	O	X	X
<i>Andrena (Andrena) frigida</i> Smith, 1853	3	April 24	3-5	2-7	C	N	S	S	O	X	X
<i>Andrena (Andrena) mandibularis</i> Robertson, 1892	3	May 9-May 27	4-6	3-7	C	N	S	S	P	X	X
<i>Andrena (Andrena) milvaukeensis</i> Graenicher, 1903	15	April 14-June 10	4-7	3-8	C	N	S	S	P	X	X
<i>Andrena (Andrena) rufosignata</i> Cockerell, 1902	14	April 14-June 2	4-6	4-8	C	N	S	S	P	X	X
<i>Andrena (Andrena) tridens</i> Robertson, 1902	2	May 5-May 27	3-5	3-7	F	N	S	S	P		
<i>Andrena (Callandrena s.l.) krigiana</i> Robertson, 1901	7	June 2-June 10	5-7	3-7	F	N	S	S	O		
<i>Andrena (Callandrena s.l.) simplex</i> Smith, 1853	10	Sept 11-Oct 16	8-9	7-9	C	N	S	S	O	X	X
<i>Andrena (Cnemidandrena) hirticincta</i> Provancher, 1888	3	Aug 28-Sept 21	8-9	8-10	C	N	S	S	O	X	X
<i>Andrena (Cnemidandrena) nubecula</i> Smith, 1853	5	Aug 14-Sept 29	7-10	7-10	C	N	S	S	O	X	X
<i>Andrena (Conandrena) bradleyi</i> Viereck, 1907	82	April 16-May 27	4-6	3-9	F	N	S	S	O	X	X
<i>Andrena (Devandrena) ziziaeformis</i> Cockerell, 1908	2	May 18-June 2	4-6	4-6	U	N	S	S	P		
<i>Andrena (Euandrena) algida</i> Smith, 1853	1	April 16	3-6	3-8	F	N	S	S	P		
<i>Andrena (Gonandrena) fragilis</i> Smith, 1853	8	June 10-June 24	5-7	5-7	C	N	S	S	O	X	X
<i>Andrena (Gonandrena) cressonii</i> Robertson, 1891	20	April 14-June 24	4-6	3-8	A	N	S	S	P	X	X
<i>Andrena (Iomelissa) violae</i> Robertson, 1891	3	May 9-June 2	5-6	4-7	R	N	S	S	O	X	X
<i>Andrena (Larandrena) miserabilis</i> Cresson, 1872	38	April 16-June 24	3-7	1-7	A	N	S	S	P	X	X
<i>Andrena (Melandrena) carlini</i> Cockerell, 1901	157	April 14-June 10	3-6	3-7	C	N	S	S	P	X	X
<i>Andrena (Melandrena) confederata</i> Viereck, 1917	1	June 10	6	2-6	U	N	S	S	P	X	X
<i>Andrena (Melandrena) dunniingi</i> Cockerell, 1898	2	May 9-May 18	3-6	2-7	A	N	S	S	P	X	X

Species	BRF individuals	BRF flight period	NY flight period	Nearctic flight period	NY abundance	Native vs. Exotic	Nest Substrate	Sociality	Pollen specificity	New York City	Ihaca
<i>Andrena (Melandrena) hilaris</i> Smith, 1853	2	May 27-June 10	5	3-7	U	N	S	S	P	X	
<i>Andrena (Melandrena) nivalis</i> Smith, 1853	4	May 27-June 10	4-7	2-8	F	N	S	S	P		X
<i>Andrena (Melandrena) pruni</i> Robertson, 1891	36	May 5-July 8	5-6	3-6	F	N	S	S	P	X	X
<i>Andrena (Melandrena) vicina</i> Smith, 1853	22	May 9-June 24	4-6	3-7	A	N	S	S	P	X	X
<i>Andrena (Platandrena) crataegi</i> Robertson, 1893	44	May 18-June 24	5-7	3-8	A	N	S	S	P	X	X
<i>Andrena (Rlucaudrena) robertsonii</i> Dalla Torre, 1896	53	May 9-July 26	5-7	4-8	C	N	S	S	P	X	X
<i>Andrena (Scaphandrena) arabis</i> Robertson, 1897	5	May 5-June 10	4-6	4-5	C	N	S	S	O	X?	
<i>Andrena (Scrapteropsis) alleghaniensis</i> Viereck, 1907	4	June 2-June 10	5-7	4-7	C	N	S	S	P	X	X
<i>Andrena (Scrapteropsis) imitatrix</i> Cresson, 1872	58	April 14-June 24	3-6	3-7	A	N	S	S	P	X	X
<i>Andrena (Siniandrena) nasonii</i> Robertson, 1895	67	May 5-June 10	4-6	3-7	A	N	S	S	P	X	X
<i>Andrena (Taeniandrena) wilkella</i> (Kirby, 1802)	20	May 27-Aug 14	4-8	4-9	A	E	S	S	P	X	X
<i>Andrena (Thysandrena) bisaltica</i> Viereck, 1908	8	April 14-June 10	3-6	2-9	F	N	S	S	P	X	X
<i>Andrena (Trachandrena) canotli</i> Viereck, 1917	3	May 18-June 24	5-6	5-6	F	N	S	S	P	X	X
<i>Andrena (Trachandrena) forbesii</i> Robertson, 1891	4	April 24-June 24	4-6	4-6	C	N	S	S	P	X	X
<i>Andrena (Trachandrena) hippotes</i> Robertson, 1895	1	May 18	4-6	4-6	C	N	S	S	P	X	X
<i>Andrena (Trachandrena) nuda</i> Robertson, 1891	38	May 18-June 24	4-6	4-6	F	N	S	S	P	X	X
<i>Andrena (Trachandrena) rugosa</i> Robertson, 1891	52	April 16-June 24	4-6	4-6	A	N	S	S	P	X	X
<i>Andrena (Trachandrena) spiraeana</i> Robertson, 1895	3	July 8-July 26	6-8	6-8	F	N	S	S	P	X	X
<i>Andrena (Tylandrena) perplexa</i> Smith, 1853	4	May 18-June 10	4-6	3-6	C	N	S	S	P	X	X
<i>Callispis (Callispis) andreniformis</i> Smith, 1853	4	July 8-Aug 15	6-8	4-10	C	N	S	S	P	X	X
<i>Pseudopanurgus andrenoides</i> (Smith, 1853)	21	Aug 28-Oct 16	8-10	8-10	C	N	S	S	O	X	X
<i>Anthidium (Proanthidium) oblongatum</i> (Illiger, 1806)	10	July 17-Sept 11	6-10	6-10	A	E	S	S	P	X	X
<i>Stelis (Dolichostelis) louisae</i> Cockerell, 1911	1	July 26	7-8	3-10	U	N	-	P	-		
<i>Stelis (Stelis) nitida</i> Cresson, 1878	1	June 24	6-7	6-7	R	N	-	P	-		
<i>Hervies (Neotrypetes) carinatus</i> Cresson, 1864	25	July 8-Aug 28	6-9	4-9	C	N	C	S	P	X	
<i>Hoplitis (Alcidama) producta</i> (Cresson, 1864)	5	June 10-July 26	5-7	4-7	C	N	C	S	P		
<i>Hoplitis (Monumetha) spoliata</i> (Provancher, 1888)	2	July 8-July 26	6-8	4-8	F	N	C	S	P		
<i>Osmia (Melanosmia) atriventris</i> Cresson, 1864	16	May 9-Aug 14	4-7	4-7	C	N	C	S	P		
<i>Osmia (Melanosmia) bucephala</i> Cresson, 1864	30	May 9-July 8	4-6	4-6	C	N	C	S	P	X	X

Appendix 1. Continued.

Species	BRF individuals	BRF flight period	NY flight period	Nearctic flight period	NY abundance	Native vs. Exotic	Nest Substrate	Sociality	Pollen specificity	New York City	Ithaca
<i>Osmia (Melanosmia) collinsiae</i> Robertson, 1905	1	May 18	4-6	4-6	U	N	C	S	P		X
<i>Osmia (Melanosmia) distincta</i> Cresson, 1864	1	June 24	5-6	5-6	F	N	C	S	P		X
<i>Osmia (Melanosmia) feltri</i> Cockerell, 1911	1	May 9	5-6	6	R	N	C	S	P		X
<i>Osmia (Melanosmia) inermis</i> (Zetterstedt, 1838)	1	June 24	5-7	5-7	U	N	C	S	O		
<i>Osmia (Melanosmia) inspergens</i> Lovell & Cockerell, 1907	9	June 2-July 26	5-6	5-6	F	N	C	S	P		X
<i>Osmia (Melanosmia) pumila</i> Cresson, 1864	145	April 24-July 8	4-7	4-7	C	N	C	S	P	X	X
<i>Osmia (Osmia) cornifrons</i> (Radoszkowski, 1887)	65	April 24-June 24	4-6	4-6	C	E	C	S	P	X	X
<i>Osmia (Osmia) lignaria</i> Say, 1837	4	April 24-May 18	3-6	3-6	C	N	C	S	P	X	X
<i>Megachile (Callomegachile) sculpturalis</i> Smith, 1853	3	Sept 6	6-9	6-9	C	E	C	S	P	X	X
<i>Megachile (Chelostomoides) campanulae</i> (Robertson, 1903)	5	July 26-Sept 6	6-9	2-11	C	N	C	S	P	X	X
<i>Megachile (Litomegachile) mendica</i> Cresson, 1878	15	July 8-Sept 11	5-10	5-10	C	N	C	S	P	X	X
<i>Megachile (Megachile) montiruga</i> Cresson, 1878	1	Sept 11	7-9	4-9	U	N	C	S	P	X	X
<i>Megachile (Megachile) relativa</i> Cresson, 1878	11	June 24-Sept 11	5-9	5-10	C	N	C	S	P	X	X
<i>Megachile (Sayapis) pugnata</i> Say, 1837	1	July 26	6-9	6-9	F	N	C	S	O	X	X
<i>Megachile (Xanthosarus) gemula</i> Cresson, 1878	11	June 2-July 26	6-8	4-8	F	N	C	S	P	X	X
<i>Coelioxys (Boreocoelioxys) octodentata</i> Say, 1824	1	Aug 24	6-9	5-10	C	N	-	P	-	X	X
<i>Coelioxys (Cyrtocoelioxys) modesta</i> Smith, 1854	1	July 17	6-8	6-8	F	N	-	P	-	X	X
<i>Xylocopa (Xylocopoides) virginica</i> (Linnaeus, 1771)	2[+]	June 10-Aug 14	3-10	3-10	C	N	-	B	-	X	X
<i>Ceratina (Zadontomerus) calcarata</i> Robertson, 1900	63	May 9-Sept 11	3-10	3-10	A	N	C	B	-	X	X
<i>Ceratina (Zadontomerus) dupla</i> Say, 1837	21	May 18-Sept 11	4-9	4-9	C	N	C	B	-	X	X
<i>Ceratina (Zadontomerus) calcarata/dupla</i>	61	May 18-Sept 21									
<i>Nomada australis</i> Mitchell, 1962	1	June 10	5-6	4-6	U	N	-	P	-	X	
<i>Nomada bella</i> Cresson, 1863	67	April 14-May 18	3-4	3-4	C	N	-	P	-	X	X
<i>Nomada cressonii</i> Robertson, 1893	38	May 9-June 24	4-7	4-7	C	N	-	P	-	X	X
<i>Nomada cuneata</i> (Robertson, 1903)	13	May 27-June 24	5-6	5-6	F	N	-	P	-	X	X
<i>Nomada denticulata</i> Robertson, 1902	35	May 9-July 26	5-6	5-6	F	N	-	P	-	X	X
<i>Nomada depressa</i> Cresson, 1863	2[+]	May 18-June 10	4-7	4-7	F	N	-	P	-	X	X
<i>Nomada illinoensis</i> Robertson, 1900	3	May 5-May 18	4-6	4-6	F	N	-	P	-	X	X
<i>Nomada lehighensis</i> Cockerell, 1903	7	April 16-June 2	4-6	4-6	F	N	-	P	-	X	X

## Appendix 1. Continued.

Species	BRF individuals	BRF flight period	NY flight period	Nearctic flight period	NY abundance	Native vs. Exotic	Nest Substrate	Sociality	Pollen specificity	New York City	Ithaca
<i>Nomiada lepida</i> Cresson, 1863	2[+]	May 9-June 24	5-7	5-7	C	N	-	P	-	X	X
<i>Nomiada luteoloides</i> Robertson, 1895	38	May 5-June 24	4-7	4-7	C	N	-	P	-	X	X
<i>Nomiada maculata</i> Cresson, 1863	61	April 24-June 24	4-6	4-6	C	N	-	P	-	X	X
<i>Nomiada ovata</i> (Robertson, 1903)	104	May 9-June 24	5-6	5-6	F	N	-	P	-	X	X
<i>Nomiada parva</i> Robertson, 1900	1	May 18	4-6	4-6	U	N	-	P	-	X	X
<i>Nomiada perplexa</i> Cresson, 1863	34	April 16-June 24	6-7	6-7	F	N	-	P	-	X	X
<i>Nomiada pygmaea</i> Cresson, 1863	35	May 5-July 26	4-6	4-6	C	N	-	P	-	X	X
<i>Nomiada sayi</i> Robertson, 1893	1[+]	May 18	4-7	4-7	F	N	-	P	-	X	X
<i>Nomiada xanthura</i> Cockerell, 1908	12	April 24-June 10	4-6	4-6	F	N	-	P	-	X	X
<i>Nomiada ruficornis</i> group undet. without tooth	118	April 14-June 24									
<i>Nomiada ruficornis</i> group with tooth ( <i>Gnathias sensu</i> Mitchell)	29	May 9-June 24									
<i>Melissoides (Eumelissoides) denticulata</i> Smith, 1854	2	Aug 28	7-9	5-10	F	N	S	S	O	X	X
<i>Melissoides (Eumelissoides) subbillata</i> LaBerge, 1961	2	July 26	7-8	6-9	F	N	S	S	O	X	X
<i>Anthophora (Clisodon) terminalis</i> Cresson, 1869	8	July 8-Sept 6	6-9	5-9	C	N	W	S	P	X	X
<i>Bombus (Psithyrus) citrinus</i> (Smith, 1854)	157	May 18-Oct 1	5-10	5-10	C	N	-	P	-	X	X
<i>Bombus (Separatobombus) griseocollis</i> (DeGeer, 1773)	1	July 8	4-9	2-10	C	N	H	E	-	X	X
<i>Bombus (Pyrobombus) bimaculatus</i> Cresson, 1863	76	May 5-July 26	4-9	2-9	C	N	H	E	-	X	X
<i>Bombus (Pyrobombus) impatiens</i> Cresson, 1863	845	April 16-Oct 16	4-11	1-11	A	N	H	E	-	X	X
<i>Bombus (Pyrobombus) perplexus</i> Cresson, 1863	61	April 24-Aug 14	4-10	4-10	C	N	H	E	-	X	X
<i>Bombus (Pyrobombus) sandersoni</i> Franklin, 1913	110	April 14-Oct 16	4-10	4-10	U	N	H	E	-		
<i>Bombus (Pyrobombus) ternarius</i> Say, 1837	2	June 10-Sept 21	4-10	4-10	C	N	H	E	-		X
<i>Bombus (Pyrobombus) vagans</i> Smith, 1854	4	Sept 29-Oct 16	5-10	5-10	C	N	H	E	-	X	X
<i>Bombus (Pyrobombus) undet.</i>	5	June 24-Sept 29									
<i>Apis (Apis) mellifera</i> Linnaeus, 1758	9[+]	June 2-Oct 16	2-12	1-12	A	E	H	E	-	X	X

## Appendix 2. List of wasp species collected incidentally at BRF in 2003.

Family	Subfamily	Species
Crabronidae	Astatinae	<i>Astata leuthstromi</i> Ashmead, 1897
Crabronidae	Bembecinae	<i>Bicyrtes quadrifasciata</i> (Say, 1824)
Crabronidae	Bembecinae	<i>Gorytes deceptor</i> Krombein, 1958
Crabronidae	Crabroninae	<i>Ectemnius (Clytochrysus) lapidarius</i> (Panzer, 1804)
Crabronidae	Crabroninae	<i>Ectemnius (Ectemnius) atriceps</i> (Cresson, 1865)
Crabronidae	Crabroninae	<i>Ectemnius (Ectemnius) borealis</i> (Zetterstedt, 1838)
Crabronidae	Crabroninae	<i>Ectemnius (Ectemnius) dives</i> (Lepeletier & Brullé, 1834)
Crabronidae	Crabroninae	<i>Ectemnius (Hypocrabro) continuus</i> (Fabricius, 1804)
Crabronidae	Crabroninae	<i>Ectemnius (Hypocrabro) decemmaculatus</i> (Say, 1823)
Crabronidae	Crabroninae	<i>Ectemnius (Hypocrabro) stirpicola</i> (Packard, 1866)
Crabronidae	Crabroninae	<i>Liris (Leptolarra) argentata</i> (Beauvois, 1811)
Crabronidae	Crabroninae	<i>Lyroda subita</i> (Say, 1837)
Crabronidae	Crabroninae	<i>Trypoxylon (Trypargilum) lactitarse</i> Saussure, 1867
Crabronidae	Crabroninae	<i>Trypoxylon (Trypoxylon) frigidum</i> Smith, 1856
Crabronidae	Crabroninae	<i>Trypoxylon (Trypoxylon) pennsylvanicum</i> Saussure, 1867
Crabronidae	Pemphredoninae	<i>Pemphredon (Cemonus) inornata</i> Say, 1824
Crabronidae	Pemphredoninae	<i>Pemphredon (Cemonus) rugifera</i> Dahlbom
Crabronidae	Pemphredoninae	<i>Mimumesa nigra</i> (Packard, 1867)
Crabronidae	Pemphredoninae	<i>Psen erythropoda</i> Rohwer, 1910
Crabronidae	Pemphredoninae	<i>Pseneo simplicicornis</i> (Fox, 1898)
Crabronidae	Philanthinae	<i>Cerceris atramontensis</i> Banks, 1913
Crabronidae	Philanthinae	<i>Cerceris fumipennis</i> Say, 1837
Crabronidae	Philanthinae	<i>Cerceris halone</i> Banks, 1912
Crabronidae	Philanthinae	<i>Philanthus gibbosus</i> (Fabricius, 1775)
Sphecidae	Sphecinae	<i>Isodontia (Isodontia) philadelphica</i> (Lepeletier, 1845)
Sphecidae	Sphecinae	<i>Isodontia (Murrayella) mexicana</i> (Saussure, 1867)
Vespidae	Eumeninae	<i>Parancistrocerus pedestris</i> (Saussure, 1855)
Vespidae	Eumeninae	<i>Parancistrocerus pensylvanicus</i> (Saussure, 1855)
Vespidae	Eumeninae	<i>Parancistrocerus perennis</i> (Saussure, 1857)
Vespidae	Eumeninae	<i>Euodynerus foraminatus</i> (Saussure, 1853)
Vespidae	Eumeninae	<i>Euodynerus hidalgo</i> (Saussure, 1857)
Vespidae	Eumeninae	<i>Euodynerus leucomelas</i> (Saussure, 1855)
Vespidae	Eumeninae	<i>Ancistrocerus adiabatatus</i> (Saussure, 1852)
Vespidae	Eumeninae	<i>Ancistrocerus antilope</i> (Panzer, 1798)
Vespidae	Eumeninae	<i>Ancistrocerus campestris</i> (Saussure, 1852)
Vespidae	Eumeninae	<i>Ancistrocerus waldenii</i> (Viereck, 1906)
Vespidae	Eumeninae	<i>Symmorplus (Symmorplus) canadensis</i> (Saussure, 1855)
Vespidae	Eumeninae	<i>Eumenes (Eumenes) fraternus</i> Say, 1824
Vespidae	Eumeninae	<i>Zethus (Zethus) spinipes</i> Say, 1837
Vespidae	Polistinae	<i>Polistes dominulus</i> (Christ, 1791)
Vespidae	Polistinae	<i>Polistes fuscatus</i> (Fabricius, 1793)
Vespidae	Vespinae	<i>Dolichovespula arenaria</i> (Fabricius, 1775)
Vespidae	Vespinae	<i>Dolichovespula maculata</i> (Linnaeus, 1758)
Vespidae	Vespinae	<i>Vespula consobrina</i> (Saussure, 1864)
Vespidae	Vespinae	<i>Vespula flavopilosa</i> Jacobson, 1978
Vespidae	Vespinae	<i>Vespula germanica</i> (Fabricius, 1793)
Vespidae	Vespinae	<i>Vespula maculifrons</i> (Buysson, 1905)
Vespidae	Vespinae	<i>Vespula vidua</i> (Saussure, 1854)
Scoliidae	Scoliinae	<i>Scolia (Discolia) bicincta</i> Fabricius, 1775
Pompilidae	Ceropalinae	<i>Ceropaltes maculata</i> (Fabricius, 1775)